IS 10047 (1981): Methods for testing refractory ramming masses [MTD 15: Refractories]

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IS : 10047 - 1981
(Reaffirmed 2002)

Indian Standard

METHODS OF TESTING REFRACTORY RAMMING MASSES

UDC 666·762·032·8 : 620·1

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 3

September 1982

Indian Standard

METHODS OF TESTING REFRACTORY RAMMING MASSES

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Indian Standard

METHODS OF TESTING REFRACTORY RAMMING MASSES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 30 December 1981, after the draft finalized by the Refractories Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard is intended to be used for assessment of the quality of refractory ramming masses as well as for checking their conformity to the specifications.

0.3 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

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1. SCOPE

1.1 This standard prescribes the methods of sampling and test for refractory ramming masses.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions and those given in IS : 4041-1967† shall apply.

2.1 Ramming Mass — Mixtures of graded refractory aggregate with or without air/heat-setting additive and with or without moisture. It is usually supplied at a consistency which requires mechanical method of application. A plasticizing agent may also be incorporated in the ramming masses.

2.2 Lot — In any consignment, all the containers containing refractory ramming mass of the same type (to be used under the same service conditions) and grade, manufactured by the same firm under similar condition of production shall be grouped together to constitute a lot. The maximum mass of any lot, however, shall be limited to 25 tonnes.

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*Rules for rounding off numerical values (*revised*).
†Glossary of terms relating to refractory materials.

3. SAMPLING AND TEST PIECE PREPARATION

3.1 For the complete series of tests, a minimum sample of about 50 kg is required. Consignments of these materials are usually supplied in 50 kg containers and the number of containers, as sample, shall be selected at random on the following basis:

Lot Weight	*No. of 50 kg Containers to be Selected as Sample*
Up to 1 tonne	1
Over 1 tonne up to and including 4 tonnes	2
Over 4 tonnes up to and including 25 tonnes	5

3.1.1 Where the material to be supplied includes a liquid component, supplied separately, the sample of liquid shall be selected on the following basis:

Lot Size of Ramming Mass	*Sample Size of Liquid Component*
Up to 4 tonnes	2 kg from one container
Over 4 tonnes up to 10 tonnes	Total 5 kg from two containers
Over 10 up to 25 tonnes	Total 10 kg from four containers

3.2 The selected containers shall be emptied on a suitable surface and the material be thoroughly mixed and divided by the process of coning and quartering method. The sample shall be reduced to 50 kg in the case of lot sizes up to 10 tonnes and 75 kg in the case of lot sizes over 10 tonnes. This final sample shall be divided equally into eight test samples by successive coning and quartering method. These test samples shall be used for various physical tests for moisture determination, sieve analysis, bulk density, firing shrinkage, pyrometric cone equivalent, modulus of rupture, cold crushing strength. thermal conductivity and also chemical analysis. It may be noted that the same test sample may be used for more than one test if permitted by respective test methods.

3.3 Preparation of Test Pieces — The method of preparing test pieces of the material has a marked effect on their properties and it is necessary to use a standard procedure.

3.3.1 *Apparatus* — The apparatus consists of a modified sand rammer (*see* Fig. 1). It comprises a means for supporting the weight, so that the load may be removed from the vertical shaft and the provision of graduated steel rule is attached to the rammer to indicate the position of the end of the shaft and consequently the uniformity in the compaction for a batch of test prisms.

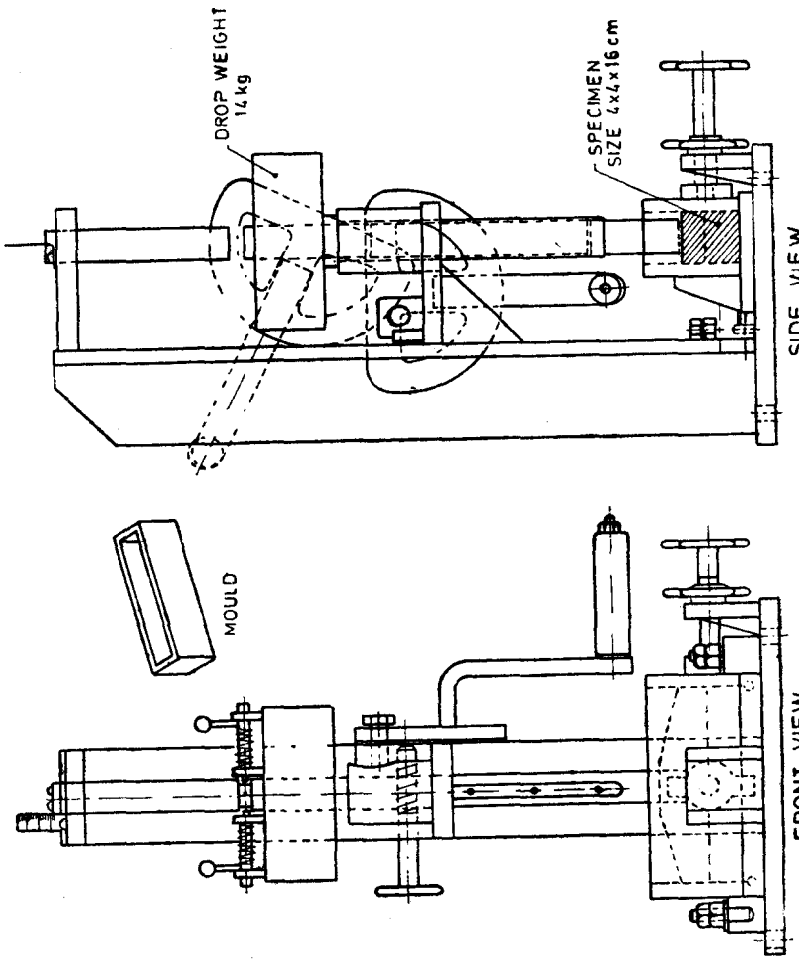


FIG. 1 EQUIPMENT FOR COMPACTING SPECIMENS

3.3.2 *Test Pieces* — The test pieces used for all the tests, excepting thermal conductivity, shall be in the shape of prisms 40 × 40 × 160 mm, when the grog size does not exceed 10 mm, and 230 × 113 × 65 mm when the grog size exceeds 10 mm. The modified sand rammer shall be used for preparing the test pieces by controlling the number of strokes of the plunger, to attain maximum compaction. In the case of larger specimens, only pneumatic ramming shall be used, also to obtain maximum compaction. (The consistency of the material, for the test pieces, shall be as per the instructions given by the manufacturer.) The mould used for preparing the specimens shall be in accordance with IS : 4031-1968*.

All the prisms, prepared as test pieces, shall be dried in air for 24 hours and for a further period of 24 hours at a temperature of 105-110°C.

4. DETERMINATION OF MOISTURE CONTENT

4.1 Out of one part of the sample, selected in accordance with **3.2**, weigh out 500 g for moisture determination, chemical analysis and pyrometric cone equivalent (PCE) determination. After thorough mixing, 100 g of the sample shall be taken for moisture determination.

4.2 Weigh accurately about 100 g of the sample in a tared weighing dish. Dry it in a uniformly heated oven for about 12 hours at 105-110°C till the mass is constant.

4.2.1 Calculate the percentage moisture by the following formula:

$$\text{Moisture, percent} = A/B \times 100$$

where

A = loss of mass of the sample in g on heating, and

B = mass in g of the sample taken.

5. SIEVE ANALYSIS

5.1 Wet sieve analysis for ramming masses, which has been just mixed, shall be carried out in accordance with IS : 1528 (Part XIV)-1974†. The sieve analysis sample shall be drawn as soon as possible, before the ramming mass stiffens.

5.1.1 *Wet Analysis* — Weigh out 250 g of dried sample from the material intended for sieve analysis after thorough mixing and coning and quartering. The test sample shall be placed in a container of about one litre capacity. Sufficient water shall be added to it to form a slurry. The slurry is to be

*Methods of physical tests for hydraulic cement.

†Methods of sampling and physical tests for refractory materials: Part XIV Determination of sieve analysis (*first revision*).

transferred without loss to the finest sieve to be used in the analysis and shall then be washed by means of a small jet of water from a 6 mm rubber hose until the water passing through the sieves contains only traces of sample. It may be required to break up lumpy material by gentle rubbing between the fingers. The washed residue in the sieve shall be dried to constant mass at 110°C. The dried residue shall then be transferred to the top of coarsest sieve of the sieves to be used.

The wet sieve analysis shall be calculated for the test sample on the dry mass basis and the results reported to the nearest 0·1 percent of material retained on each sieve. The percentage passing the finest sieve shall be reported as the difference between 100 percent and the sum of the percentages retained on the various sieves.

6. CHEMICAL ANALYSIS

6.1 For high silica ramming masses, the chemical analysis shall be carried out in accordance with IS : 1527-1972*. For other type of ramming masses, the method of analysis shall be as agreed to between the manufacturer and the purchaser.

6.1.1 It is not necessary to analyse separately the wet and dry components of the ramming masses. In the case of two-component ramming masses, the analysis shall be preferably carried out on rammed and hardened sample, which has been hardened by drying at 110°C.

7. DETERMINATION OF BULK DENSITY

7.1 Test Specimens — 40 × 160 mm cast specimen, prepared in accordance with **3.3.2** or fired specimens shall be used.

7.2 Test Method — Bulk density shall be determined in accordance with IS : 1528 (Part XII)-1974†, on three test specimens.

8. DETERMINATION OF LINEAR CHANGE AFTER FIRING

8.1 Test Specimens — The same three specimens, as that used for determining bulk density, shall be used.

8.2 Test Method — The prisms are set in the furnace and fired in oxidizing atmosphere to the test temperature. The furnace shall be heated up to 500°C in one hour, and thereafter at a rate not exceeding 300°C/hour up to the

*Methods for chemical analysis of high silica refractory materials (*first revision*).

†Method of sampling and physical tests for refractory materials: Part XII Determination of bulk density (*first revision*).

appropriate test temperature. The maximum temperature shall be maintained within $\pm 10°C$ for three hours and the furnace then allowed to cool naturally. After cooling to the room temperature, the final linear measurements shall be taken. The shrinkage or expansion shall be calculated with respect to the original dimensions.

9. DETERMINATION OF MODULUS OF RUPTURE (MOR)

9.1 Test Specimens — $40 \times 40 \times 160$ mm specimens prepared in accordance with 3.3.2 shall be used for determining the modulus of rupture after conducting the test for determination of linear change after firing.

9.2 Test Method — Any suitable central loading apparatus which is capable of the specified rate of loading and of accurate measurement in the required range may be used (*see* Fig. 2). The test specimens measuring $40 \times 40 \times 160$ mm shall be placed in the apparatus at room temperature so that the single bearing edge is applied to the top face. The span shall be 100 mm and the load shall be applied in the middle. Apply the load at a rate of 50 ± 10 N/s until the fracture occurs and note the maximum load. The MOR is calculated using the formula:

$$R = 3\ Wl/2\ bd^2$$

where

R = modulus of rupture in N/mm^2,

W = load in Newton at which the specimen fails,

l = distance between the centre lines of the lower bearing edges in mm,

b = width of the specimens in mm, and

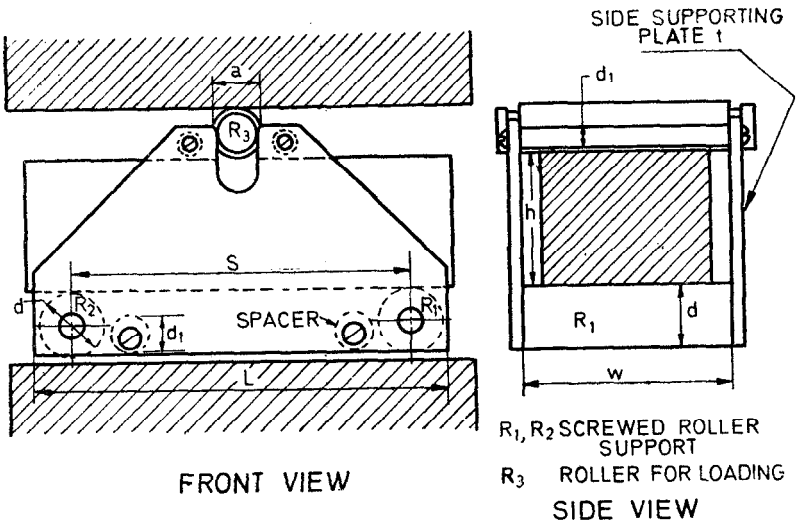
d = depth of the specimen in mm.

The test shall be carried out on 3 prisms.

9.2.1 Modulus of rupture test may be carried out by the above method on test prisms, which have been cooled after having been pre-fired at any test temperature, as agreed to between the manufacturer and the purchaser.

10. DETERMINATION OF COLD CRUSHING STRENGTH (CCS)

10.1 Test Specimen — The half-prisms, obtained in the 'modulus of rupture' tests shall be used for determining the cold crushing strength. The test shall be carried out on all the six half prisms obtained after the modulus of rupture test.

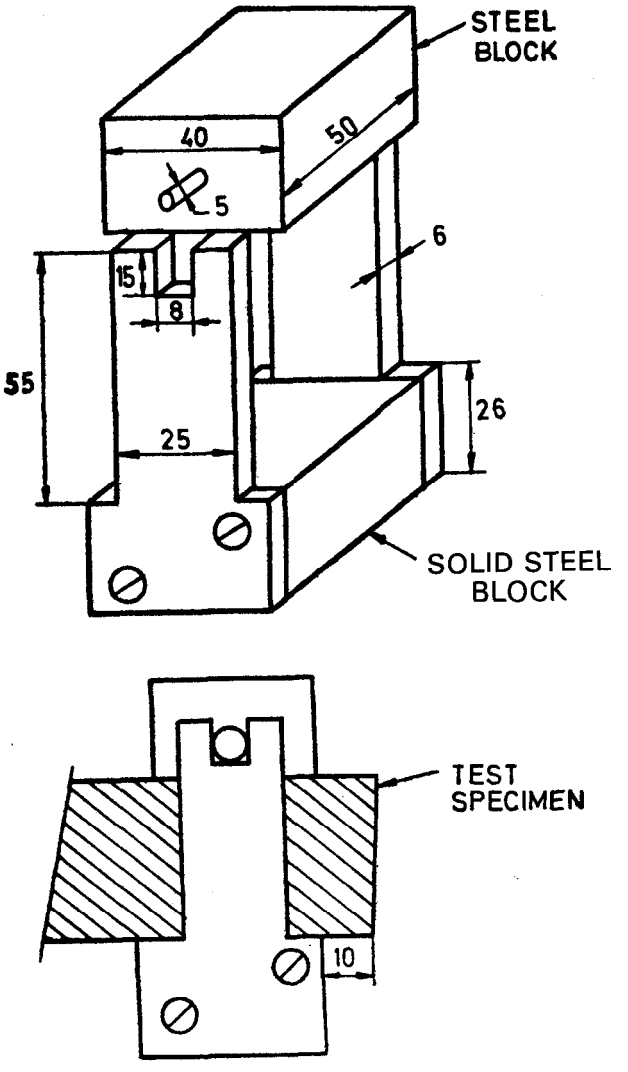


L	*d*	d_1	*S*	*t*	*a*	*w*	*h*
220	10	6	100	8	4	50	40

All dimensions in millimetres.

FIG. 2 STEEL JIG FOR MODULUS OF RUPTURE TEST

10.2 Test Method — A mechanical or hydraulic crushing strength testing machine (*see* Fig. 3), shall be used for the determination of crushing strength. Each half prism shall be tested for compressive strength on its side faces, of which an area 40 × 40 mm shall be placed between two hard metal plates. This shall be at least 10 mm thick, 40 ± 0·1 mm wide, more than 40 mm long and their surfaces shall be plane to within 0·02 mm. The plates shall preferably be of tungsten carbide or a steel with Vickers hardness index of at least 600. During the test, the plate shall be guided without any friction in such a way that the upper is maintained vertically above the lower. One of the plates may be slightly inclined to permit perfect contact between it and the face of the test specimen. The plate, test specimen and suitable guides shall be placed in a compression machine, the upper plate of which shall be mounted on a freely moving ball, seating centrally on the axis of compression. The side or diameter of this platten shall not be larger than 10 cm on account of the sample size of the test specimens.



All dimensions in millimetres.

FIG. 3 LOADING ARRANGEMENT FOR CCS ON BROKEN PRISMS AFTER MOR TEST

The machine shall have an accuracy of $\pm 1{\cdot}5$ percent for the smallest loads used in the test. The load shall be increased at the rate of 100 N/cm^2 up to about half the expected crushing load and continued till the specimen breaks. The load shall be applied uniformly. The CCS shall be calculated in the following way:

$$CCS = W/A$$

where

W = total maximum load in Newtons; and
A = area of the specimen, in cm^2.

10.2.1 The average value of the 6 half prisms shall be reported. The above method shall be applied for all test specimens at different temperatures as agreed to by the manufacturer and purchaser.

11. DETERMINATION OF PYROMETRIC CONE EQUIVALENT (PCE)

11.0 The object of this test is to determine the softening point of the ramming masses by comparison of the test cones, prepared from the test material with the standard cones.

11.1 Test Method — The test shall be carried out in accordance with IS : 1528 (Part I)-1980*.

12. DETERMINATION OF THERMAL CONDUCTIVITY

12.1 Principle — The quantity of heat flowing at equilibrium through a test panel under specified conditions is measured. The test is carried out on a pre-fired sample. The test pieces are fired to specified temperature, at which the tests are to be conducted, and the thermal conductivity determined at hot-face temperature not exceeding the pre-firing temperature. The test may also be carried out after progressively higher pre-firing temperatures.

12.2 Test Specimens — The test sample shall be of the size 230 × 114 × 76 mm. All the samples remaining after other tests shall be mixed together and after thorough mixing a representative sample shall be taken and the requisite quantity of water or any other liquid binder as needed shall be added and rammed in a mould (of size 230 × 114 × 76 mm) with a steel tamping tool. After completion of the moulding, the test sample shall be air dried for 24 hours and dried at 110°C for another 24 hours. It is advisable to pre-fire the sample at 500°C or at any other temperature for 5 hours and cooled before carrying out the thermal conductivity test.

12.3 Test Method — The thermal conductivity test shall be carried out by any suitable method as agreed to between the supplier and the purchaser.

*Methods of sampling and physical tests for refractory materials: Part I Determination of pyrometric cone equivalent (PCE) or softening point (*second revision*).

(*Continued from page* 2)

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